SYSTEM AND METHOD FOR SURGICAL GUIDANCE AND INTRA-OPERATIVE PATHOLOGY THROUGH ENDO-MICROSCOPIC TISSUE DIFFERENTIATION

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application is a divisional of U.S. patent application Ser. No. 15/568,219 filed on Oct. 20, 2017, which is a U.S. National Phase Application of PCT/US2015/030095 filed on May 11, 2015, the contents of which are incorporated by reference.

BACKGROUND OF THE INVENTION

[0002] The present invention relates generally to surgical guidance and tissue differentiation, and more particularly to surgical guidance and intra-operative pathology through endo-microscopic tissue differentiation.

[0003] The therapy of choice for most malignant and benign tumors in the human body is the surgical attempt aimed at total resection of the tumor with preservation of normal functional tissue, followed by radio-chemotherapy. An incomplete resection of a tumor with remaining infiltrative growing cells increases the risk of recurrence with adjacent therapies, decreases the quality of life, and elevates the risk of mortality. Diagnosis of tumor and definition of tumor borders intra-operatively is primarily based on the visualization modalities, where for example a surgeon takes a limited number of biopsy specimens which are later examined through histopathology performed as quickly as possible to provide proper feedback during the surgery. Unfortunately, intraoperative fast histopathology is often not sufficiently informative, due to freezing artifacts, mechanical tissue destruction, and tissue architecture alteration during the sample preparation. In addition, sampling errors are another source of inaccuracy. Optimal surgical therapy, which is the combination of maximal near total resection and minimal injury of the normal tissue, is only achieved if the surgeon is able to identify intra-operatively the tissue cellular structures and differentiate tumorous from normal functional tissue.

BRIEF SUMMARY OF THE INVENTION

[0004] In accordance with an embodiment, systems and methods for image classification include receiving imaging data of in-vivo or excised tissue of a patient during a surgical procedure. Local image features are extracted from the imaging data.8 A vocabulary histogram for the imaging data is computed based on the extracted local image features. A classification of the in-vivo or excised tissue of the patient in the imaging data is determined based on the vocabulary histogram using a trained classifier, which is trained based on a set of sample images with confirmed tissue types.

[0005] In accordance with on embodiment, systems and methods for image registration include extracting personalized biomechanical parameters from a first region of tissue of a patient in an inverse problem of the biomechanical model using pre-operative imaging data and intra-operative imaging data. Correspondences are identified between an outer layer of a second region of the tissue in the pre-operative imaging data and the outer layer of the second region of the tissue in the intra-operative imaging data. A deformation of an inner layer of the second region of the tissue in the pre-operative imaging data is determined based on the identified correspondences by applying the biomechanical model with the personalized biomechanical parameters.

[0006] In accordance with one embodiment, systems and methods for performing tumor resection on a brain of a patient include registering pre-operative imaging data and intra-operative imaging data. The registered pre-operative imaging data and intra-operative imaging data are displayed. A confocal laser endomicroscopy (CLE) probe is navigated to a region of in-vivo or excised brain tissue including the tumor based on the displaying the registered pre-operative imaging data and intra-operative imaging data. CLE imaging data is received from the CLE probe at a border of the tumor. A classification of the region of the in-vivo or excised brain tissue is determined as at least one of healthy tissue and tumorous tissue. The classification of the in-vivo or excised brain tissue is displayed for resection of the tumor. The determining the classification of the region of the in-vivo or excised brain tissue and the displaying the classification of the in-vivo or excised brain tissue are repeated until the displaying the classification of the in-vivo or excised brain tissue shows healthy tissue with a resected tumor bed.

[0007] These and other advantages of the invention will be apparent to those of ordinary skill in the art by reference to the following detailed description and the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] FIG. **1** shows a system for image guidance and classification, in accordance with one embodiment;

[0009] FIG. **2** shows illustrative images of tissue deformation after craniotomy, in accordance with one embodiment;

[0010] FIG. **3** shows a high-level framework for image classification, in accordance with one embodiment;

[0011] FIG. **4** illustratively shows images having low texture information, in accordance with one embodiment;

[0012] FIG. **5** illustratively shows local image feature sampling inside a region of interest of an intra-operative image, in accordance with one embodiment;

[0013] FIG. **6** shows an overview of vocabulary tree training, in accordance with one embodiment;

[0014] FIG. **7** shows an exemplary display of a workstation, in accordance with one embodiment;

[0015] FIG. **8** shows a method for image guidance and classification, in accordance with one embodiment;

[0016] FIG. **9** shows a detailed method for registering pre-operative imaging data and intra-operative imaging data based on a personalized biomechanical model, in accordance with one embodiment;

[0017] FIG. **10** shows a detailed method for classifying tissue, in accordance with one embodiment;

[0018] FIG. **11** shows a high-level workflow for a tumor resection procedure of the brain, in accordance with one embodiment; and

[0019] FIG. **12** shows a high-level block diagram of a computer for image guidance and classification, in accordance with one embodiment.